IN THE CLAIMS

Claim 1 (Currently Amended): A low-alloy heat-resistant steel comprising:

carbon in an amount of 0.20 to 0.35% by weight,

silicon in an amount of 0.005 to 0.35% by weight,

manganese in an amount of 0.05 to 1.0% by weight,

nickel in an amount of 0.05 to 0.3% by weight,

chromium in an amount of 0.8 to 2.5% by weight,

molybdenum in an amount of 0.1 to 1.5% by weight,

tungsten in an amount of 0.1 to 2.5% by weight,

vanadium in an amount of 0.05 to 0.3% by weight,

phosphorus in an amount not greater than 0.012% by weight,

sulfur in an amount not greater than 0.005% by weight,

copper in an amount not greater than 0.10% by weight,

aluminum in an amount not greater than 0.01% by weight,

arsenic in an amount not greater than 0.01% by weight,

tin in an amount not greater than 0.01% by weight,

antimony in an amount not greater than 0.003% by weight, and

the balance being iron and unavoidable impurities, and

containing a metallic structure having ~~an austenitic~~ a grain size number in a range of from 3 to 6.

Claim 2 (Currently Amended): A low-alloy heat-resistant steel comprising:

carbon in an amount of 0.20 to 0.35% by weight,

silicon in an amount of 0.005 to 0.35% by weight,

manganese in an amount of 0.05 to 1.0% by weight,

nickel in an amount of 0.05 to 0.3% by weight,

chromium in an amount of 0.8 to 2.5% by weight,

molybdenum in an amount of 0.1 to 1.5% by weight,

tungsten in an amount of 0.1 to 2.5% by weight,

vanadium in an amount of 0.05 to 0.3% by weight,

cobalt in an amount of 0.1 to 3.5% by weight,

phosphorus in an amount not greater than 0.012% by weight,

sulfur in an amount not greater than 0.005% by weight,

copper in an amount not greater than 0.10% by weight,

aluminum in an amount not greater than 0.01% by weight,

arsenic in an amount not greater than 0.01% by weight,

tin in an amount not greater than 0.01% by weight,

antimony in an amount not greater than 0.003% by weight, and

the balance being iron and unavoidable impurities, and

containing a metallic structure having ~~an austenitic~~ a grain size number in a range of from 3 to 6.

Claim 3 (Currently Amended): A low-alloy heat-resistant steel comprising:

carbon in an amount of 0.20 to 0.35% by weight,

silicon in an amount of 0.005 to 0.35% by weight,

manganese in an amount of 0.05 to 1.0% by weight,

nickel in an amount of 0.05 to 0.3% by weight,

chromium in an amount of 0.8 to 2.5% by weight,

molybdenum in an amount of 0.1 to 1.5% by weight,

tungsten in an amount of 0.1 to 2.5% by weight,

vanadium in an amount of 0.05 to 0.3% by weight,

at least one of niobium in an amount of 0.01 to 0.15% by weight, tantalum in an amount of 0.01 to 0.15% by weight, nitrogen in an amount of 0.001 to 0.05% by weight, and boron in an amount of 0.001 to 0.015% by weight,

phosphorus in an amount not greater than 0.012% by weight,

sulfur in an amount not greater than 0.005% by weight,

copper in an amount not greater than 0.10% by weight,

aluminum in an amount not greater than 0.01% by weight,

arsenic in an amount not greater than 0.01% by weight,

tin in an amount not greater than 0.01% by weight,

antimony in an amount not greater than 0.003% by weight, and

the balance being iron and unavoidable impurities, and

containing a metallic structure having ~~an austenitic~~ a grain size number in a range of from 3 to 6.

Claim 4 (Currently Amended): A low-alloy heat-resistant steel comprising:

carbon in an amount of 0.20 to 0.35% by weight,

silicon in an amount of 0.005 to 0.35% by weight,

manganese in an amount of 0.05 to 1.0% by weight,

nickel in an amount of 0.05 to 0.3% by weight,

chromium in an amount of 0.8 to 2.5% by weight,

molybdenum in an amount of 0.1 to 1.5% by weight,

tungsten in an amount of 0.1 to 2.5% by weight,

vanadium in an amount of 0.05 to 0.3% by weight,

cobalt in an amount of 0.1 to 3.5% by weight,

at least one of niobium in an amount of 0.01 to 0.15% by weight, tantalum in an amount of 0.01 to 0.15% by weight, nitrogen in an amount of 0.001 to 0.05% by weight, and boron in an amount of 0.001 to 0.015% by weight,

phosphorus in an amount not greater than 0.012% by weight,

sulfur in an amount not greater than 0.005% by weight,

copper in an amount not greater than 0.10% by weight,

aluminum in an amount not greater than 0.01% by weight,

arsenic in an amount not greater than 0.01% by weight,

tin in an amount not greater than 0.01% by weight,

antimony in an amount not greater than 0.003% by weight, and

the balance being iron and unavoidable impurities, and

containing a metallic structure having ~~an austenitic~~ a grain size number in a range of from 3 to 6.

Claim 5 (Original): A low-alloy heat-resistant steel according to claim 1, wherein said metallic structure mainly contains a bainite phase and a pro-eutectoid ferrite phase.

Claim 6 (Original): A low-alloy heat-resistant steel according to claim 2, wherein said metallic structure mainly contains a bainite phase and a pro-eutectoid ferrite phase.

Claim 7 (Original): A low-alloy heat-resistant steel according to claim 3, wherein said metallic structure mainly contains a bainite phase and a pro-eutectoid ferrite phase.

Claim 8 (Original): A low-alloy heat-resistant steel according to claim 4, wherein said metallic structure mainly contains a bainite phase and a pro-eutectoid ferrite phase.

Claim 9 (Original): A low-alloy heat-resistant steel according to claim 1, wherein said metallic structure contains a pro-eutectoid ferrite phase in a range of from 5 to 40% by volume.

Claim 10 (Original): A low-alloy heat-resistant steel according to claim 2, wherein said metallic structure contains a pro-eutectoid ferrite phase in a range of from 5 to 40% by volume.

Claim 11 (Original): A low-alloy heat-resistant steel according to claim 3, wherein said metallic structure contains a pro-eutectoid ferrite phase in a range of from 5 to 40% by volume.

Claim 12 (Original): A low-alloy heat-resistant steel according to claim 4, wherein said metallic structure contains a pro-eutectoid ferrite phase in a range of from 5 to 40% by volume.

Claim 13 (Currently Amended): A low-alloy heat-resistant steel according to claim 1, wherein said metallic structure contains a pro-eutectoid ferrite phase, and ~~carbnitrides~~ carbonitrides are finely dispersed into said pro-eutectoid ferrite phase.

Claim 14 (Currently Amended): A low-alloy heat-resistant steel according to claim 2, wherein said metallic structure contains a pro-eutectoid ferrite phase, and ~~carbnitrides~~ carbonitrides are finely dispersed into said pro-eutectoid ferrite phase.

Claim 15 (Currently Amended): A low-alloy heat-resistant steel according to claim 3, wherein said metallic structure contains a pro-eutectoid ferrite phase, and ~~carbnitrides~~ carbonitrides are finely dispersed into said pro-eutectoid ferrite phase.

Claim 16 (Currently Amended): A low-alloy heat-resistant steel according to claim 4, wherein said metallic structure contains a pro-eutectoid ferrite phase, and ~~carbnitrides~~ carbonitrides are finely dispersed into said pro-eutectoid ferrite phase.

Claim 17 (Withdrawn – Currently Amended): A ~~heat-treatment~~ method ~~for~~ of making a low-alloy heat-resistant steel, the method comprising ~~the steps of~~:

heating a steel ingot to a range of from 1,000 to 1,100℃, which comprises carbon in an amount of 0.20 to 0.35% by weight, silicon in an amount of 0.005 to 0.35% by weight, manganese in an amount of 0.05 to 1.0% by weight, nickel in an amount of 0.05 to 0.3% by weight, chromium in an amount of 0.8 to 2.5% by weight, molybdenum in an amount of 0.1 to 1.5% by weight, tungsten in an amount of 0.1 to 2.5% by weight, vanadium in an amount of 0.05 to 0.3% by weight, and the balance being iron and unavoidable impurities;

cooling said steel ingot to a certain temperature in a range of from 900 to 700℃ by a spray-quenching and/or an air-blast quenching,

air cooling for from 5 minutes to 5 hours,

cooling again by at least one method of a spray-quenching, an air-blast quenching, and an oil quenching, and

producing the steel of claim 1.

Claim 18 (Withdrawn – Currently Amended): A ~~heat-treatment~~ method ~~for~~ of making a low-alloy heat-resistant steel, the method comprising ~~the steps of~~:

heating a steel ingot to a range of from 1,000 to 1,100℃, which comprises carbon in an amount of 0.20 to 0.35% by weight, silicon in an amount of 0.005 to 0.35% by weight, manganese in an amount of 0.05 to 1.0% by weight, nickel in an amount of 0.05 to 0.3% by weight, chromium in an amount of 0.8 to 2.5% by weight, molybdenum in an amount of 0.1 to 1.5% by weight, tungsten in an amount of 0.1 to 2.5% by weight, vanadium in an amount of 0.05 to 0.3% by weight, and the balance being iron and unavoidable impurities;

cooling said steel ingot to a temperature in a range of from 800 to 600℃ at an average cooling rate of 2℃/min or less; ~~and~~

cooling to 300℃ at an average cooling rate in a range of from 2 to 15℃/min; and

producing the steel of Claim 1.

Claim 19 (Withdrawn – Currently Amended): A ~~heat-treatment~~ method according to claim 17, wherein said steel ingot further comprises at least one of niobium in an amount of 0.01 to 0.15% by weight, tantalum in an amount of 0.01 to 0.15% by weight, cobalt in an amount of 0.1 to 3.5% by weight, nitrogen in an amount of 0.001 to 0.05% by weight, and boron in an amount of 0.001 to 0.015% by weight.

Claim 20 (Withdrawn – Currently Amended): A ~~heat-treatment~~ method according to claim 18, wherein said steel ingot further comprises at least one of niobium in an amount of 0.01 to 0.15% by weight, tantalum in an amount of 0.01 to 0.15% by weight, cobalt in an amount of 0.1 to 3.5% by weight, nitrogen in an amount of 0.001 to 0.05% by weight, and boron in an amount of 0.001 to 0.015% by weight.

Claim 21 (Withdrawn – Currently Amended): A ~~heat treatment~~ method according to claim 17, wherein said unavoidable impurities contain phosphorus in an amount not greater than 0.012% by weight, sulfur in an amount not greater than 0.005% by weight, copper in an amount not greater than 0.10% by weight, aluminum in an amount not greater than 0.01% by weight, arsenic in an amount not greater than 0.01% by weight, tin in an amount not greater than 0.01% by weight, and antimony in an amount not greater than 0.003% by weight.

Claim 22 (Withdrawn – Currently Amended): A ~~heat treatment~~ method according to claim 18, wherein said unavoidable impurities contain phosphorus in an amount not greater than 0.012% by weight, sulfur in an amount not greater than 0.005% by weight, copper in an amount not greater than 0.10% by weight, aluminum in an amount not greater than 0.01% by weight, arsenic in an amount not greater than 0.01% by weight, tin in an amount not greater than 0.01% by weight, and antimony in an amount not greater than 0.003% by weight.

Claim 23 (Currently Amended): A turbine rotor comprising ~~a~~ the low-alloy heat-resistant steel ~~according to~~ of claim 1.

Claim 24 (Currently Amended): A turbine rotor comprising ~~a~~ the low-alloy heat-resistant steel ~~according to~~ of claim 2.

Claim 25 (Currently Amended): A turbine rotor comprising ~~a~~ the low-alloy heat-resistant steel ~~according to~~ of claim 3.

Claim 26 (Currently Amended): A turbine rotor comprising ~~a~~ the low-alloy heat-resistant steel ~~according to~~ of claim 4.

SUPPORT FOR THE AMENDMENT

This Amendment amends Claims 1-4 and 13-26. Support for the amendments is found in the specification and claims as originally filed. In particular, support for replacing "an austenitic grain size number" with --a grain size number-- in Claims 1-4 is found in the specification at least at page 3, last paragraph, to page 4, second paragraph (e.g., "In the present invention, the ferritic grain size determination for steel comprising mixed crystal grains, which is defined by JIS G 0552 (1998), is adopted") and at page 36, lines 4-6 ("The crystal grain size number was measured by the ferritic grain size determination for steels comprising mixed crystal grains, which is defined by JIS G 0552 (1998)"). A copy of JIS G 0552 (1998) is attached. No new matter would be introduced by entry of these amendments.

Upon entry of these amendments, Claims 1-26 will be pending in this application. Claims 1-4 are independent. Claims 17-22 are withdrawn from consideration pursuant to a Restriction Requirement.

ELECTION

Applicants hereby affirm the provisional election with traverse of August 11, 2003, to prosecute the invention of Group I (Claims 1-16 and 23-26).

REQUEST FOR RECONSIDERATION

Applicants respectfully request entry of the foregoing and reexamination and reconsideration of the application, as amended, in light of the remarks that follow.

Applicants thank the Examiner for the courtesies extended to their representative during the October 7, 2003, personal interview.

As discussed at the interview, the present invention provides low-alloy heat-resistant steels with high creep embrittlement resistance. Applicants' steel includes nickel at an

amount of 0.05 to 0.3% by weight. Nickel has the effect of enhancing the toughness as well as enhancing the hardenability during heat treatment and improving the tensile strength and the yield strength. If the nickel content is less than 0.05%, these effects are not discernable. In order to eliminate the harmful effect of nickel on long-term creep rupture strength, the upper limit of the nickel content is 0.3%. See, specification at page 21, lines 1-11.

Claims 1-4 and 23-26 are rejected under 35 U.S.C. § 103(a) over Japanese Patent No. 62-278251 ("JP-251") or M. Yamada, et al., Clean Steel; Super Clean Steel, pages 109-122, XP-002204194 ("Yamada").

JP-251 discloses a low-alloy steel containing 0.5-4.00% by weight Ni. JP-251 at English-language abstract and page 269, first column.

Yamada discloses an alloy containing 1.7 wt% Ni. Yamada at Table 2 on page 116.

However, JP-251 and Yamada fail to suggest the limitation of independent Claims 1-4 of a steel comprising: "nickel in an amount of 0.05 to 0.3% by weight". Thus, the rejection over JP-251 or Yamada should be withdrawn.

Claims 2, 4, 6, 8, 10, 12, 14, 16, 24 and 26 are further patentably distinguishable over JP-251 and Yamada, because JP-251 and Yamada are silent about and fail to suggest the limitation of independent Claims 2 and 4 of "cobalt in an amount of 0.1 to 3.5% by weight". As shown in the specification and summarized below by comparing Sample Nos. 1 and 3 (no Co) with Sample 4 (1.48 wt% Co), the 0.1 to 3.5 wt% Co provides the steel of the present invention with superior creep properties.

Table 1-1

Material No.	Chemical Composition (wt%)												
	C	Si	Mn	Ni	Cr	Mo	W	V	Nb	Ta	Co	N	B
1	0.26	0.05	0.09	0.08	1.46	0.54	2.40	0.25					
3	0.31	0.03	0.23	0.09	1.04	0.52	2.42	0.24					
4	0.27	0.08	0.20	0.09	1.35	1.20	2.38	0.24			1.48		

Material No.	Chemical Composition (wt%)							
	P	S	Cu	Al	As	Sn	Sb	Fe
1	0.006	0.001	0.03	0.003	0.006	0.005	0.0012	balance
3	0.006	0.001	0.01	0.003	0.006	0.005	0.0015	balance
4	0.006	0.001	0.01	0.002	0.006	0.005	0.0013	balance

Table 1-2

	Sample No.	Material No.	Crystal grain size number	Precipitation amount of pro-eutectoid ferrite phase (Vol%)
Example 1	1-7	1	3.8	22
	1-8	1	4.2	23
Example 3	3-1	3	3.7	16
	3-2	3	4.0	25
Example 4	4-1	4	3.7	27
	4-2	4	4.0	20

Table 1-3

	Sample No.	Material characteristic					
		0.2% Yield (MPa)	Charpy impact absorbed energy (J)	Creep rupture test at 600℃ and 147 MPa			
				Unnotched creep rupture time (h) A	Unnotched creep rupture ratio (%)	Notched creep rupture time (h) B	Creep rupture time ratio B/A
Example 1	1-7	609	55	6,570	79.9	more than 14,000	2.13 or greater
	1-8	614	51	6,470	81.2	more than 14,000	2.19 or greater
Example 3	3-1	628	38	7,252	77.3	more than 14,000	1.93 or greater
	3-2	626	37	7,026	81.0	more than 14,000	1.99 or greater
Example 4	4-1	618	46	8,071	76.5	more than 14,000	1.73 or greater
	4-2	625	59	8,237	79.4	more than 14,000	1.70 or greater

Claims 5-16 are rejected under 35 U.S.C. § 103(a) over European Patent No. 1091010 ("Fujita"). Fujita was published on April 11, 2001. In contrast, Applicants are entitled to the priority of Japanese Application No. P2001-061842 of March 6, 2001. To perfect Applicants' claim to priority under 37 C.F.R. § 1.55, attached is an English-language translation of Japanese Application No. P2001-061842. Because Applicants' priority date of March 6, 2001 is prior to the publication date of Fujita of April 11, 2001, Fujita is not prior art to the above-identified application. Thus, the rejection over Fujita should be withdrawn.

Claims 1-16 and 23-26 are rejected under 35 U.S.C. § 112, second paragraph. Applicants respectfully traverse the rejection.

Austenite is a Fe-C phase that exists in equilibrium above approximately 723°C. See. e.g., Foundations of Materials Science and Engineering, page 429, copy attached. However, at lower temperatures austenite transforms into various microstructures containing ferrite and cementite (Fe_3C), such as microstructures containing the "bainite" and "pro-eutectoid ferrite" phases recited in Claims 5-16, depending upon the manner in which the austenite is cooled. See, e.g., Introduction to Mechanical Properties of Materials, page 393, copy attached.

The term "austenitic grain size" can be defined as "the size attained by the grains of steel when heated to the austentic region; may be revealed by appropriate etching of cross sections after cooling to room temperature." See, Metals Handbook, Desk Edition, page 1.3, copy attached. Thus, the determination of the austenitic grain size number of a metallic structure does not require, after austenitic grains are initially formed, the presence of austenite.

Because the presence of austenite is not required for a metallic structure to be characterized by an austenitic grain size number, Applicants submit that the limitation of "a metallic structure having an austenitic grain size number in a range of from 3 to 6" is not

indefinite. In addition, because bainite and pro-eutectoid ferrite are phases that exist at room temperature, Applicants submit that the limitation that "said metallic structure mainly contains a bainite phase and a pro-eutectoid ferrite phase" is not indefinite. In any event, in light of the amendment of Claims 1-4 replacing "an austenitic grain size number" with --a grain size number--, Applicants submit that the rejection under 35 U.S.C. § 112, second paragraph is moot and should be withdrawn. Applicants thank the Examiner for the indication at the October 7, 2003, personal interview that the rejection under 35 U.S.C. § 112, second paragraph will be withdrawn. See Interview Summary dated October 7, 2003.

Pursuant to MPEP § 821.04, after independent product Claim 1 is allowed, Applicants respectfully request rejoinder, examination and allowance of withdrawn method Claims 17-22, which include all of the limitations of product Claim 1.

In view of the foregoing amendments and remarks, Applicants respectfully submit that the application is in condition for allowance. Applicants respectfully request favorable consideration and prompt allowance of the application.

Should the Examiner believe that anything further is necessary in order to place the application in even better condition for allowance, the Examiner is invited to contact Applicants' undersigned attorney at the telephone number listed below.

Respectfully submitted,

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Attachments:

JIS G 0552 (1998)
English-language translation of Japanese Application No. P2001-061842
Foundations of Materials Science and Engineering, page 429
Introduction to Mechanical Properties of Materials, page 393
Metals Handbook, Desk Edition, page 1.3

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